ASSOCIATION OF CHLOROPHYLL A WITH PHYSICAL AND CHEMICAL FACTORS IN LAKE ONTARIO, 1967-1981

A.H. El-Shaarawi[1], J. Richard Elliott[2], R.E. Kwiatkowski[3] and David R. Peirson[4]

[1]National Water Research Institute, Burlington, Ontario
Department of Mathematics[3] and Biology[4]
Wilfrid Laurier University, Waterloo, Ontario

1. INTRODUCTION

Eutrophication is a naturally-occurring process in all lakes. However, the rate at which a lake proceeds from an oligotrophic state (limited nutrient availability) to an eutrophic state (excessive nutrient availability) can be accelerated by anthropogenic inputs. The most visibile impact of eutrophication on an aquatic ecosystem is that of increased biomass/number of biological organisms, particularly at the primary producer (algae) level. This excessive increase in biomass has been responsible for tainted drinking water supplies, reduced or depleted oxygen levels in the hypolimnetic (cold, deep) waters of lakes, beaches clogged with dead or decaying algal mats, and overall impairment of the aquatic resource, making it unsuitble for other desirable uses.

Concerned about the deterioration of the water quality of the lower Great Lakes due to eutrophication (International Lake Erie Water Pollution Board and the International Lake Ontario-St. Lawrence Water Pollution Board, 1969), the governments of Canada and the United States signed the 1972 Canada-United State Great Lakes Water Quality Agreement (renewed in 1978). Though whole lake water quality sampling of Lake Ontario has occurred since 1967, a surveillance program specifically addressing the requirements of the Agreements was initiated in 1974.

One of the objectives of the surveillance program was to describe lake conditions on a spatial and temporal basis. Due to the fact that increased biomass is an expected effect of increased nutrient loadings (Vollenweider, 1976), it was concluded that the cumulative progress of eutrophication could be described by the long-term periodic measurement of phytoplankton standing stocks (Watson et al., 1975).

Two methods were readily available for measurement of phytoplankton biomass. Direct enumeration and cell volume measurement with subsequent biomass calculation, or indirectly through chlorophyll a measurement. Both methods have advantages and disadvantages. Direct enumeration was costly (≈ $100.00/sample) time consuming (2 to 3 samples/day/person) and difficulties existed with accurate linear measurements of the cells and adequate dry weight estimates of the organisms. The advantage, assuming that an adequate estimate of numbers could be obtained by subsampling the parent population, was a highly accurate estimate of phytoplankton biomass. Chlorophyll a was inexpensive (≈$2.00/sample) and could be done quickly and efficiently (80 samples/day/person). The disadvantage was simply that the chlorophyll a concentration within a given phytoplankton cell varies with species, age and the overall physiological status of the algal cell, as well as the nutrient and physical environment in which the phytoplankton cell exists.

Due to the size of the Lake Ontario surveillance program (approximately 90 stations sampled monthly, Figure 1), direct phytoplankton enumeration and measurement was considered to be too costly and time prohibitive to be used as a routine surveillance parameter. As a result, chlorophyll a became the only biomass indicator routinely measured on all surveillance cruises.

Now that reductions in spring total phosphorus concentrations have been clearly documented (IJC, 1983) corresponding reductions in algae biomass are expected, as predicted by the Vollenweider model (Vollenweider, 1976). As a result, the long-term chlorophyll a data set has become a valuable historical record of the trophic status of Lake Ontario. The aim of this paper is to find if statistical relationships between chlorophyll a and other commonly

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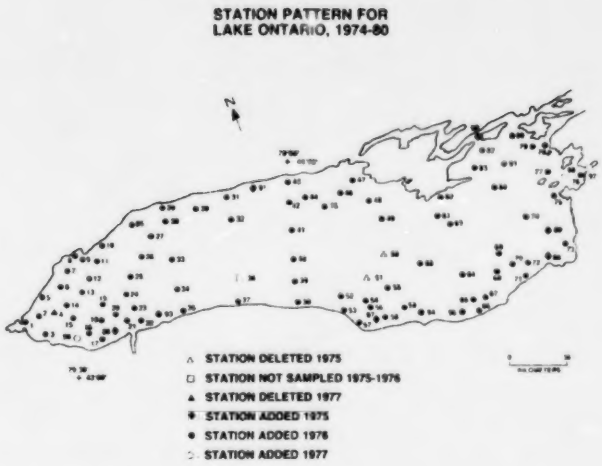

Fig. 1. Station Pattern for Lake Ontario, 1974-80.

measured water quality variables exist, and to study the stability of these relationships seasonally, as well as over time, to provide insight into the overall limnological processes influencing the trophic status of Lake Ontario.

2. MATERIALS AND METHODS

Chlorophyll *a* has been collected on all whole lake cruises on Lake Ontario since 1967. The number of cruises in any one year ranged from three (1971, 1980) to 17 (1974), while the number of stations in any given cruise ranged from 32 (1972 and 1973) to 95 (1969). It should be pointed out that in the pre-1974 years no two years had identical station and cruise patterns. Consistency in whole lake monitoring began with the surveillance cruises, starting in 1974. Similarly, changes in methodology in collection and analysis of chlorophyll *a* have occurred. For 1968 and 1969, continuous fluorometric measurements of surface waters were performed using the method

of Lorenzen (1966) to estimate the *in vivo* chlorophyll concentration. In 1970, chlorophyll was determined spectrophotometrically using the SCOR/UNESCO equation (Strickland and Parsons, 1968) at discrete depths in the water column. Starting in 1972, the chlorophyll samples were also analyzed for phacopigments (phacophytin *a* and phacophorbide *a*) using the analytical procedure described by Lorenzen (1969) and Yentsch (1970). To provide estimates of biomass phytoplankton in the top 20 metre stratum, chlorophyll samples were obtained with a 0-20 metre integrator (Schroeder, 1969) starting in 1974. Further details on cruise frequency, station location and parameter lists for the Lake Ontario cruises can be found in Kwiatkowski and Neilson, 1983.

All the data used in this study are stored on a Cyber computer at the Canada Centre for Inland Waters, Burlington, Ontario, in the STAR data base. The Lake Ontario data was stored in two files, one containing all the data from 1967 to 1973 inclusive and the other containing the data from 1974 on. The values required for the study were retrieved from the data base using the general access program PRET1 which was the most efficient retrieval program available.

The variables retrieved for investigation were chlorophyll *a* (µg/ℓ), sounding depth of station (metals), total phosphorus (mg P/ℓ), soluble reactive phosphorus (mg P/ℓ), integrated total particulate nitrogen (mg N/ℓ), temperature at the sampling point (deg. C), secchi depth (meters), soluble reactive silica (mg SiO_2/ℓ) and integrated particulate organic carbon (mg C/ℓ). From 1967 to 1973 measurements of integrated total particulate nitrogen were not frequently recorded, so ammonia and nitrate/nitrite (both in mg N/ℓ) measurements were retrieved. Further details on analytical methods and field procedures can be found in Department of the Environment (1974), and Watson and Williams (1975).

Due to differences in sampling techniques, various sorting programs were required to select stations at which chlorophyll had been sampled and to combine these data into a single record for further analysis. SORT1 was applied to data from the period 1967 to July 1969, during which all relevant variables were measured at the water surface. For data collected between July 1969 and 1971, all of the variables

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3. RESULTS

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except temperature and chlorophyll were measured at a depth of one meter, and the program SORT2 was used to combine the one meter readings on these variables with the surface data on the remaining variables. In 1972 and 1973, most cruises sampled fewer than 75 stations and had surface data only so SORT1 was used for these; for the remaining cruises which sampled more than 75 stations, all of the variables except temperature were measured at a one meter depth and SORT3 was applied to these data. From 1974 on, integrated sampling was used for total particulate nitrogen, total phosphorus, particulate organic carbon and chlorophyll. To generate comparable readings for the remaining variables, SORT4 averaged all of the corresponding readings from 20 meters or less for each variable per station.

Some data sets were analysed more than once as not all variables were measured at each station. For example, a variable such as secchi depth would be measured often enough for analysis but including it would reduce the possible sample size by approximately one-third. In other instances, one or more variables would be consistently measured at stations where others were not. Consequently, the data would become partitioned into two subsets containing different sets of variables. The second analysis was not performed unless the alternate data set seemed large enough to warrant it.

3. RESULTS

The following tables and graphs summarize the results of the regressions on the 1967 to 1984 data. Cruises are identified by their starting dates. Tables 1.1 to 1.4 contain maximum R-squared values for each cruise together with the number of cases for each regression. This R-squared value is the total value for the equation using the default conditions in the program for entering variables. There is a minor drop in the R-squared values in July and August which can be seen more clearly in the results from the years 1974 to 1981. This drop is most easily identified in Figure 2, which graphs the obtained R-squareds versus Julian days for the period 1974-1981, inclusively. Tables 2.1 to 2.4 indicate the rating given each variable entered into the equation by the stepwise

TABLE 1.1 R^2 values for regressions done on data from 1967 to 1971

	Date		R^2			Number of Cases		Number of Variables	
	Jan 11	(70)	.61			13		7	
**	Feb 3	(70)	.60			46		6	
**	Mar 30	(70)	.49			49		7	
**	Mar 31	(71)	.93	(**)	.54	21	18	8	7
**	Mar 31	(70)	.59			20		3	
**	Apr 12	(69)	.80			17		7	
NS	Apr 27	(71)	(**)						
**	Apr 28	(70)	.71			37		3	
**	Apr 30	(68)	.67			24		5	
**	May 1	(69)	.71			19		3	
**	May 12	(69)	.76			30		8	
**	May 25	(70)	.67			37		2	
**	May 29	(68)	.97			13		6	
NS	Jun 3	(69)	.20			12		3	
**	Jun 9	(69)	.52			37		8	
**	Jun 20	(69)	.86			14		3	
**	Jun 22	(70)	.45			40		3	
**	Jul 2	(68)	.34			31		6	
NS	Jul 8	(69)	.46			23		7	
NS	Jul 10	(67)	.11			31		5	
NS	Jul 16	(70)	.09			37		3	
	Jul 23	(68)							
**	Jul 29	(67)	.52			25		5	
**	Aug 5	(67)	.31			34		4	
**	Aug 5	(69)	.88			21		7	
**	Aug 9	(71)	.84	(**)	.68	17	36	8	7
NS	Aug 17	(70)	.11			33		3	
	Aug 19	(68)							
NS	Aug 21	(67)	.83			38		3	
	Aug 21	(69)							
**	Sep 5	(67)	.53			33		4	
	Sep 8	(68)							
**	Sep 10	(69)	.78			22		1	
**	Sep 14	(70)	.34			28		3	
**	Sep 16	(67)	.66			21		5	
**	Oct 1	(67)	.79			27		5	
**	Oct 2	(69)	.67	(	) .19	16		8	7
NS	Oct 5	(68)	.92			16	39	6	
**	Oct 8	(70)	.86			26		3	
**	Oct 17	(67)	.47			25		4	
**	Oct 27	(68)	.60			30		7	
**	Oct 28	(67)	.67			22		5	
**	Oct 31	(69)	.89	(**)	.44	24	59	8	7
NS	Nov 15	(71)	.56	(**)	.21	15	42	8	6
NS	Nov 16	(70)	.00			23		3	
*	Nov 18	(68)	.91			19		7	
**	Dec 1	(69)	.85	(**)	.73	18	54	7	7
**	Dec 8	(70)	.40			22		3	

* Significant at the 5% level
**Significant at the 1% level

regression program. The rating was obtained by multiplying its order of entry by the total number of variables available (8 for 1967 to 1972 and 9 for 1974 to 1981), and then dividing by the number of variables which actually entered the equation. An average rating for each variable was then obtained. This was done to facilitate comparison of the importance of each variable between equations and over all equations. In Tables 1 and 2, a line under the number

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TABLE 1.2 R^2 values for regressions done on data from 1972 to 1973

	Date		R^2	Number of Cases	Number of Variables
**	Jan 3	(73) (1)	.79	19	2
**	Jan 3	(73) (2)	.73	33	2
**	Jan 8	(73)	.81	23	2
**	Jan 9	(73)	.94	19	7
**	Jan 15	(73)	.84	37	2
**	Jan 16	(73)	.84	44	2
**	Jan 29	(73)	.93	17	2
**	Jan 30	(73)	.94	21	2
**	Feb 12	(73)	.73	17	3
**	Feb 26	(73)	.85	17	3
*	Mar 6	(73)	.40	29	7
**	Mar 12	(73)	.47	23	3
**	Mar 13	(73)	.33	44	2
**	Mar 26	(73)	.61	26	3
**	Mar 27	(73)	.42	43	2
**	Apr 4	(72)	.60	24	3
**	Apr 5	(72)	.53	43	2
**	Apr 10	(72)	.74	25	3
**	Apr 10	(72) A	.95	15	8
**	Apr 10	(72) B	.74	32	7
**	Apr 11	(72)	.50	19	3
**	Apr 17	(72)	.58	24	3
**	Apr 18	(72)	.62	16	3
**	Apr 24	(72)	.81	23	3
**	Apr 25	(72)	.76	18	3
**	May 1	(72)	.75	31	3
**	May 2	(72)	.79	19	3
**	May 8	(72)	.59	28	3
NS	May 9	(72)	.78	20	3
	May 23	(72)	.88	16	8
NS	May 23	(72)	.66	31	7
**	Jun 19	(72)	.84	31	7
**	Sep 5	(72)	.80	24	7
NS	Oct 3	(72)	.15	18	3
**	Oct 17	(72)	.84	31	7
**	Oct 30	(73) A	.56	17	8
**	Oct 30	(73) B	.51	59	7
**	Nov 20	(72)	.77	32	7
**	Dec 5	(72) (1)	.38	43	2
**	Dec 5	(72) (2)	.70	19	3
**	Dec 11	(72)	.87	17	3
**	Dec 12	(72)	.63	40	2
**	Dec 18	(72)	.86	37	2
**	Dec 19	(72)	.75	21	2

indicates that the variable was significant at the 5% level.

From the averages obtained in Table 2, the most important variables were determined by choosing variables with the lowest ratings. In the years 1967 to 1971 the three most important variables were secchi depth (third at the 1% level), nitrate/nitrite nitrogen (second at the 1% level and first at the 5% level) and temperature (first at the 1% level and second at the 5% level). In 1972 and 1973, the three most important variables were nitrate/nitrite nitrogen (third at the 1% level), soluble reactive silica (second at the 1% level and first at the 5% level) and soluble reactive phosphorous (first at the 1% level and second at the 5% level). For the

TABLE 1.3 R^2 values for regressions done on data from 1974 to 1977

	Date			R^2	Number of Cases	Number of Variables
**	Mar 15	(77)	A	.96	31	7
**	Mar 15	(77)	B	.88	71	6
**	Apr 5	(76)	A	.93	20	7
**	Apr 5	(76)	B	.93	48	6
**	Apr 11	(75)	A	.95	21	8
**	Apr 11	(75)	B	.90	45	7
**	Apr 12	(77)	A	.92	50	7
**	Apr 12	(77)	B	.86	87	6
**	Apr 16	(74)	A	.86	19	5
**	Apr 16	(74)	B	.83	38	4
**	Apr 26	(76)	A	.95	24	5
**	Apr 26	(76)	B	.94	47	4
*	Apr 29	(74)	A	.93	16	5
**	Apr 29	(74)	B	.96	40	4
**	May 9	(77)	A	.94	48	7
**	May 9	(77)	B	.90	93	6
**	May 13	(74)	A	.92	21	6
**	May 13	(74)	B	.72	40	5
**	May 23	(75)	A	.79	23	5
**	May 23	(75)	B	.69	43	4
**	Jun 2	(75)	A	.93	17	8
**	Jun 2	(75)	B	.92	28	7
**	Jun 3	(74)	A	.89	22	5
**	Jun 3	(74)	B	.78	40	4
**	Jun 6	(77)	A	.95	31	7
**	Jun 6	(77)	B	.90	53	6
**	Jun 7	(76)	A	.95	24	7
**	Jun 7	(76)	B	.84	46	6
*	Jun 17	(74)	A	.78	27	5
**	Jun 17	(74)	B	.38	42	4
**	Jun 28	(76)	A	.82	14	6
**	Jun 28	(76)	B	.64	23	5
**	Jun 28	(76)	C	.79	42	5
**	Jun 28	(76)	D	.65	64	4
**	Jul 2	(74)	A	.85	14	5
**	Jul 2	(75)	B	.73	20	6
NS	Jul 2	(75)	C	.38	62	4
**	Jul 18	(77)	A	.77	28	5
**	Jul 18	(77)	B	.73	82	4
*	Jul 19	(76)	A	.32	18	3
**	Jul 21	(75)	A	.60	28	5
**	Jul 21	(75)	B	.70	46	4
**	Jul 22	(74)	A	.69	30	5
**	Jul 27	(76)	A	.55	23	6
**	Jul 27	(74)	B	.63	40	7
**	Jul 27	(76)	C	.67	35	5
**	Jul 27	(76)	D	.68	58	4
**	Aug 6	(74)	A	.39	22	5
**	Aug 6	(74)	B	.17	42	4
**	Aug 12	(74)	A	.80	15	5
**	Aug 12	(74)	B	.68	30	4
**	Aug 12	(74)	C	.79	15	5
**	Aug 12	(74)	D	.54	20	4
**	Aug 12	(75)	A	.58	28	5
**	Aug 12	(75)	B	.65	46	4
**	Aug 15	(77)	A	.55	27	5
**	Aug 15	(77)	B	.76	53	4
**	Aug 17	(76)	A	.89	27	7
**	Aug 17	(76)	B	.84	47	6
*	Aug 19	(74)	A	.66	22	5
**	Aug 19	(74)	B	.77	39	4
**	Sep 2	(75)	O	.86	13	7
**	Sep 2	(75)	A	.63	24	6
**	Sep 2	(75)	B	.58	42	5
**	Sep 2	(75)	C	.70	18	6
**	Sep 2	(75)	D	.31	31	5
**	Sep 3	(74)	A	.82	20	6
**	Sep 3	(74)	B	.70	33	5

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TABLE 1.3 R^2 values for regressions done on data from 1974 to 1977 Continued

	Date		R^2	Number of Cases	Number of Variables
**	Sep 7 (76)	A	.93	29	5
**	Sep 7 (76)	B	.88	63	4
**	Sep 12 (77)	A	.73	38	7
**	Sep 12 (77)	B	.78	94	6
**	Sep 16 (74)	A	.91	24	5
**	Sep 16 (74)	B	.92	42	4
**	Sep 22 (75)	A	.91	18	6
*	Sep 22 (75)	B	.87	32	5
**	Sep 30 (74)	A	.99	22	5
**	Oct 4 (76)	A	.91	18	6
**	Oct 4 (76)	B	.91	34	5
**	Oct 4 (76)	C	.89	34	5
**	Oct 4 (76)	D	.87	65	4
**	Oct 14 (75)	A	.78	20	5
**	Oct 14 (75)	B	.72	43	4
NS	Oct 15 (74)	A	.76	20	5
**	Oct 15 (74)	B	.67	37	4
**	Oct 25 (77)	A	.93	18	7
*	Oct 25 (77)	B	.82	45	6
**	Oct 25 (77)	A	.70	19	5
**	Oct 25 (77)	B	.75	53	4
**	Nov 3 (75)	A	.89	19	5
**	Nov 3 (75)	B	.72	44	4
**	Nov 14 (77)	A	.54	18	5
**	Nov 14 (77)	B	.69	53	4
**	Nov 15 (76)	A	.96	11	6
**	Nov 15 (76)	B	.79	33	5
**	Nov 15 (76)	C	.69	28	5
**	Nov 15 (76)	D	.76	63	4
**	Nov 25 (74)	A	.84	16	6
**	Nov 25 (74)	B	.70	38	5
**	Dec 3 (76)	A	.89	21	5
**	Dec 3 (76)	B	.92	48	4
**	Dec 5 (75)	A	.86	16	5
**	Dec 5 (75)	B	.73	45	4

period 1974 to 1977, the three most important variables were soluble reactive silica (third at the 1% level), soluble reactive phosphorous (third at the 1% level and second at the 5% level) and total particulate nitrogen (first at both levels).

For all remaining summaries, results from 1967 to 1973 inclusive were excluded since no significant trends were observed. This was principally due to the numerous inconsistencies in the method of data collection, as noted above. The inconsistencies also made the results from this period virtually impossible to relate to the 1974 to 1981 data.

Examination of the data indicates that the number of variables available to the regression was lower when the R-squared value was low versus when the R-squared value was high. Total particulate nitrogen was the most common first

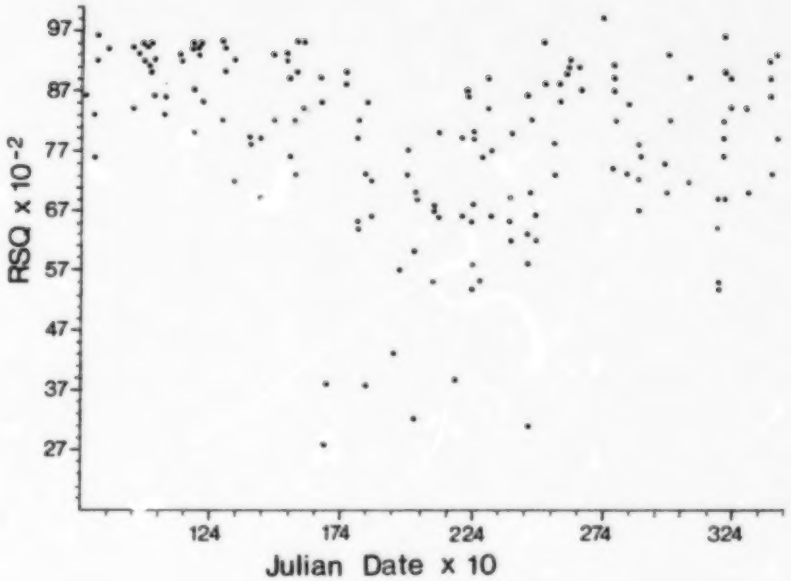

Fig. 2. R^2 values for regressions done on data from 1974 to 1981.

variable when the R-squared was low. Consistently throughout the year, the percentage of the total R-squared value accounted for the first three variables entered into the equation; they were very high, usually between 70 and 100 percent. Based on the ratings from Table 2, the three most frequently utilized variables for estimating the chlorophyll *a* concentration were integrated total particulate nitrogen, soluble reactive phosphorus and integrated particulate organic carbon, in order of their importance.

4. DISCUSSION

A number of papers have been published on the horizontal distribution of chlorophyll *a* over Lake Ontario (Chau *et al.*, 1970; Nicholson, 1970; Glooschenko *et al.*, 1972; Glooschenko *et al.*, 1973; Glooschenko and Dobson, 1975; Kwiatkowski, 1978 and Kwiatkowski, 1980). Few attempts have been made in the past to relate chlorophyll *a* concentrations to the other

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**	Apr	21
**	Apr	21
**	Apr	27
**	Apr	27
**	Apr	30
**	Apr	30
**	May	8
**	May	8
**	May	19
**	May	19
**	May	28
**	May	28
**	Jun	5
**	Jun	5
**	Jun	15
**	Jun	15
**	Jun	25
**	Jun	25
**	Jul	4
**	Jul	4
**	Jul	13
**	Jul	13
**	Jul	30
**	Jul	30
**	Aug	8
**	Aug	8
**	Aug	10
**	Aug	10
**	Aug	25
**	Aug	25
**	Aug	27
**	Aug	27
**	Sep	5
**	Sep	5
**	Sep	14
**	Sep	14
**	Sep	17
**	Sep	17
**	Oct	5
**	Oct	5
**	Oct	10
**	Oct	10
**	Nov	14
**	Nov	14
**	Nov	16
**	Nov	16
**	Nov	19
**	Nov	19
**	Dec	7
**	Dec	7

TABLE 1.4 R^2 values for regressions done on data from 1974 to 1977

	Date		R^2	Number of Cases	Number of Variables
**	Mar 16	(81) A	.86	40	7
**	Mar 16	(81) B	.86	90	6
**	Mar 20	(78) A	.83	39	7
**	Mar 20	(78) B	.76	83	6
**	Mar 21	(79) A	.96	43	7
**	Mar 21	(79) B	.92	89	6
**	Mar 24	(80) A	.94	42	7
**	Mar 24	(80) B	.94	88	6
**	Apr 4	(81) A	.94	43	7
**	Apr 4	(81) B	.84	94	6
**	Apr 8	(79) A	.95	35	7
**	Apr 8	(79) B	.92	92	6
**	Apr 10	(78) A	.94	45	7
**	Apr 10	(78) B	.91	92	6
**	Apr 21	(80) A	.93	59	7
**	Apr 21	(80) B	.92	92	6
**	Apr 27	(81) A	.87	55	5
**	Apr 27	(81) B	.80	93	4
**	Apr 30	(79) A	.95	45	7
**	Apr 30	(79) B	.85	93	6
**	May 8	(78) A	.95	27	7
**	May 8	(78) B	.82	56	6
**	May 19	(81) A	.78	62	5
**	May 19	(81) B	.79	94	4
**	May 28	(79) A	.93	35	5
**	May 28	(79) B	.82	59	4
**	Jun 5	(78) A	.82	33	7
**	Jun 5	(78) B	.73	54	6
**	Jun 15	(81) A	.89	61	5
**	Jun 15	(81) B	.85	93	4
**	Jun 25	(79) A	.90	34	5
**	Jun 25	(79) B	.88	59	4
**	Jul 4	(78) A	.66	30	5
**	Jul 4	(78) B	.72	58	4
**	Jul 13	(81) A	.57	55	5
**	Jul 13	(81) B	.43	92	4
**	Jul 30	(79) A	.80	33	5
**	Jul 30	(79) B	.66	59	4
**	Aug 8	(78) A	.79	28	5
**	Aug 8	(78) B	.66	58	4
**	Aug 10	(81) A	.86	45	7
**	Aug 10	(81) B	.87	89	6
**	Aug 25	(80) A	.65	35	7
**	Aug 25	(80) B	.69	93	6
**	Aug 27	(79) A	.80	26	5
**	Aug 27	(79) B	.62	59	4
**	Sep 5	(78) A	.66	54	7
**	Sep 5	(78) B	.62	92	6
**	Sep 14	(81) A	.88	51	5
**	Sep 14	(81) B	.85	94	4
**	Sep 17	(79) A	.91	52	7
**	Sep 17	(79) B	.90	94	6
**	Oct 5	(81) A	.74	44	5
**	Oct 5	(81) B	.82	93	4
**	Oct 10	(78) A	.85	26	5
**	Oct 10	(78) B	.73	59	4
**	Nov 14	(88) A	.55	18	5
**	Nov 14	(88) B	.64	53	4
**	Nov 16	(81) A	.90	31	7
**	Nov 16	(81) B	.82	88	6
**	Nov 19	(79) A	.89	39	7
**	Nov 19	(79) B	.84	93	6
**	Dec 7	(81) A	.93	31	5
**	Dec 7	(81) B	.79	93	4

TABLE 2.1 Rated order of variables 1967 to 1971

Date	Depth	Temp	Secchi	Silica	NH_3	NO_2,NO_3	SRP	TP
Jan 11 (70)	4.57	2.29		3.43	8.00	6.86	5.71	1.14
Feb 3 (70)	2.29	*1.14		6.86	5.71	(8.00)	4.57	3.43
Mar 3 (70)	1.14	5.00		5.71	4.57	6.86	2.29	3.43
Mar 30 (71)A	(5.00)	6.00	5.00	4.00	7.00	2.00	1.00	3.00
Mar 30 (71)B	2.29	3.43		1.14	8.00	5.71	4.57	6.86
Mar 31 (70)	2.67	5.33	8.00					
Apr 12 (69)	8.00	1.14	2.29	3.43	4.57	6.86	5.71	
Apr 28 (70)	8.00	2.67	5.33					
Apr 30 (68)	6.40	1.60		4.80	0.00	8.00	3.20	
May 1 (69)	5.33	2.67	8.00					
May 12 (69)	6.00	4.00	8.00	1.00	5.00	3.00	7.00	2.00
May 25 (70)	(8.00)	5.33	2.67					
May 27 (68)	5.71	6.86		(8.00)	4.57	1.14	2.29	3.43
Jun 3 (69)	5.33	8.00	2.67					
Jun 9 (69)	3.00	1.00	4.00	8.00	7.00	6.00	5.00	2.00
Jun 20 (69)	5.33	2.67	8.00					
Jun 22 (70)	8.00	5.33	2.67					
Jul 2 (68)	4.57	5.71		3.43	2.29	(8.00)	6.36	1.14
Jul 8 (69)	6.00	4.00	5.00	7.00	(8.00)	3.00	1.00	2.00
Jul 10 (67)	8.00	?.20	1.60	6.40	4.80			
Jul 16 (70)	8.00	5.33	2.67					
Jul 27 (67)	4.80	3.20	1.60	8.00	6.40			
Aug 5 (67)	1.60	4.80	6.40	(8.00)	3.20			
Aug 5 (69)	3.00	4.06	(5.00)	6.00	2.00	5.00	7.00	1.00
Aug 9 (71)A	4.00	2.00	8.00	7.00	3.00	6.00	5.00	1.00
Aug 9 (71)B	5.71	1.14		6.86	8.00	2.29	4.57	3.43
Aug 17 (70)	2.67	8.00	5.33					
Aug 21 (67)	2.67	8.00	5.33					
Sep 5 (67)	2.00	6.00	8.00	4.00				
Sep 10 (69)	4.00	1.00	8.00	6.00	3.00	7.00	5.00	2.00
Sep 14 (70)	8.00	5.33	2.67					
Sep 16 (67)	8.00	1.60	6.40	3.20	4.80			
Oct 1 (67)	3.20	1.60	4.80	8.00	6.40			
Oct 2 (69)A	4.00	5.00	1.00	6.00	7.00	2.00	8.00	3.00
Oct 2 (69)B	6.86	3.43		5.71	4.57	1.14	6.00	2.67
Oct 5 (68)	6.86	2.29		3.43	5.71	1.14	4.57	(8.00)
Oct 13 (70)	5.33	2.67	8.00					
Oct 17 (67)	3.20	6.40	4.80	(8.00)	1.60			
Oct 27 (68)	4.57	2.29		3.43	6.86	1.14	5.71	8.00
Oct 28 (67)	4.80	3.20	1.60	6.40	8.00			
Oct 31 (69)A	3.00	2.00	8.00	6.00	4.00	7.00	1.00	5.00
Oct 31 (69)B	3.43	2.29		4.57	6.86	8.00	1.16	5.71
Nov 15 (71)A	6.00	5.00	2.00	3.00	8.00	4.00	7.00	1.00
Nov 15 (71)B	3.43	1.14		4.57	2.29	8.00	6.86	5.71
Nov 16 (70)	5.33	8.00	2.67					
Nov 18 (68)	4.57	1.14		5.71	3.43	8.00	6.86	2.29
Dec 1 (69)A	6.00	5.00	5.00	4.00	(8.00)	7.00	2.00	1.00
Dec 1 (69)B	1.14	8.00		5.71	6.86	4.57	3.43	2.29
Dec 8 (70)	2.67	5.33	8.00					
	2.35	1.84	1.99	2.79	2.20	1.97	2.15	2.18
	3.37	2.04	3.19	3.18	2.20	1.97	2.31	2.05
	4.61	3.95	4.98	5.09	5.11	4.87	4.49	3.01

*Values underlined are significant at the 5% level

variables routinely measured on the surveillance program. Notable exceptions are Stadelmann and Fraser (1974) and Stadelmann and Munawar (1975), although these were restricted to only a few stations located on a transect of Lake Ontario over one year. Kwiatkowski and El-Shaarawi (1977) related chlorophyll a concentrations from all surveillance stations with the physio-chemical variables measured, but only for one year, 1974. The present paper represents the first attempt to

TABLE 2.2 Rated order

Date	Depth	T
Jan 3 (73)(1)	8.00	4
Jan 3 (73)(2)	8.00	2
Jan 8 (73)	8.00	2
Jan 9 (73)	4.34	
Jan 15 (73)	8.00	4
Jan 16 (73)	8.00	
Jan 29 (73)	8.00	2
Jan 30 (73)	5.00	
Feb 12 (73)	2.67	
Feb 26 (73)	5.33	
Mar 6 (73)	1.14	
Mar 12 (73)	5.33	
Mar 13 (73)	4.00	
Mar 26 (73)	2.67	
Mar 27 (73)	4.00	
Apr 4 (72)	2.67	(
Apr 5 (72)	4.00	
Apr 10 (72)	2.67	
Apr 10 (72)A	4.00	
Apr 10 (72)B	8.00	
Apr 11 (72)	5.33	
Apr 17 (72)	2.67	
Apr 18 (72)	2.67	
Apr 24 (72)	2.67	
Apr 25 (72)	5.33	
May 1 (72)	5.33	
May 2 (72)	5.33	
May 8 (72)	5.33	
May 9 (72)	5.33	
May 23 (72)A	6.00	
May 23 (72)B	8.00	
Jun 19 (72)	4.57	
Sep 5 (72)	6.86	
Oct 3 (72)	5.33	
Oct 17 (72)	4.57	
Oct 30 (73)A	4.00	
Oct 30 (73)B	2.29	
Nov 20 (72)	4.57	
Dec 5 (72)(1)	4.00	
Dec 5 (72)(2)	4.00	
Dec 11 (72)	2.67	
Dec 12 (72)	8.00	
Dec 18 (72)	8.00	
Dec 19 (72)	8.00	
	3.56	
	3.76	
	5.17	

establish if a c
and the other v
1967-1984.

In Lake Onta
by chlorophyll
spring and fall
pattern has bee
oligotrophic la

It is inte
indicators, in

TABLE 2.2 Rated order of variables 1972 to 1973

Date	Depth	Temp	Secchi	Silica	NH_3	NO_2,NO_3	SRP	TP
Jan 3 (73)(1)	8.00	4.00						
Jan 3 (73)(2)	8.00	4.00						
Jan 8 (73)	8.00	4.00						
Jan 9 (73)	4.34	5.72		(8.00)	2.29	3.43	6.86	1.14
Jan 15 (73)	8.00	4.00						
Jan 16 (73)	8.00	4.00						
Jan 29 (73)	8.00	4.00						
Jan 30 (73)	5.00	4.00						
Feb 12 (73)	2.67	5.33	8.00					
Feb 26 (73)	5.33	2.67	8.00					
Mar 6 (73)	1.14	3.43		5.72	6.86	(8.00)	4.57	2.29
Mar 12 (73)	5.33	8.00	2.67					
Mar 13 (73)	4.00	8.00						
Mar 26 (73)	2.67	5.33	8.00					
Mar 27 (73)	4.00	8.00						
Apr 4 (72)	2.67	(8.00)	5.33					
Apr 5 (72)	4.00	8.00						
Apr 10 (72)	2.67	5.33	8.00					
Apr 10 (72)A	4.00	6.00	7.00	1.00	3.00	2.00	5.00	8.00
Apr 10 (72)B	8.00	6.86		5.72	2.29	3.43	1.14	4.57
Apr 11 (72)	5.33	8.00	2.67					
Apr 17 (72)	2.67	5.33	8.00					
Apr 18 (72)	2.67	5.33	8.00					
Apr 24 (72)	2.67	5.33	8.00					
Apr 25 (72)	5.33	2.67	8.00					
May 1 (72)	5.33	2.67	8.00					
May 2 (72)	5.33	2.67	8.00					
May 8 (72)	5.33	2.67	8.00					
May 9 (72)	5.33	2.67	8.00					
May 23 (72)A	6.00	7.00	1.00	5.00	3.00	2.00	8.00	4.00
May 23 (72)B	8.00	2.29		3.43	6.84	5.72	1.14	4.57
Jun 19 (72)	4.57	8.00		1.14	3.43	5.72	6.36	2.29
Sep 5 (72)	6.86	4.57		2.29	8.00	3.43	5.72	1.14
Oct 3 (72)	5.33	8.00	2.67					
Oct 17 (72)	4.57	6.84		5.72	8.00	1.14	3.43	2.29
Oct 30 (73)A	4.00	7.00	2.00	6.00	3.00	5.00	1.00	8.00
Oct 30 (73)B	2.29	8.00		5.72	3.43	1.14	6.86	4.57
Nov 20 (72)	4.57	3.43		6.86	2.29	1.14	5.72	8.00
Dec 5 (72)(1)	4.00	8.00						
Dec 5 (72)(2)	4.00	8.00						
Dec 11 (72)	2.67	5.33	8.00					
Dec 12 (72)	8.00	4.00						
Dec 18 (72)	8.00	4.00						
Dec 19 (72)	8.00	4.00						
	3.56	3.61	2.11	1.46	2.67	1.77	1.14	2.29
	3.76	4.18	2.11	1.46	2.75	2.24	1.68	1.71
	5.17	5.27	6.37	4.60	4.37	3.10	4.68	4.24

establish if a consistent pattern exists between chlorophyll a and the other variables measured on the Lake Ontario cruises 1967-1984.

In Lake Ontario, phytoplankton biomass maxima, represented by chlorophyll a concentration, were consistently found in the spring and fall, with minima in the summer. This bimodal pattern has been reported as being typical of large temperate oligotrophic lakes (Hutchinson, 1967).

It is interesting to note that the other biomass indicators, integrated particulate organic carbon and

TABLE 2.3 Rated order of variables 1974 to 1977

Date	Depth	Temp	Secchi	Silica	ITN	ITP	SRP	IPOC
Mar 15 (77)A	5.72	8.00	4.57	2.29	1.14		3.43	6.86
Mar 15 (77)B	(8.00)	6.67		5.33	4.00		1.33	2.67
Apr 5 (76)A	5.72	3.43	2.29	4.57	6.86		1.14	8.00
Apr 5 (76)B	5.33	4.00		8.00	1.33		6.67	2.67
Apr 11 (75)A	8.00	6.00	7.00	4.00	2.00	3.00	1.00	5.00
Apr 11 (75)B	2.29	8.00		6.86	5.72	3.43	1.14	4.57
Apr 12 (77)A	4.57	5.72	(8.00)	6.86	1.14		2.29	3.43
Apr 12 (77)B	4.00	8.00		6.67	1.33		5.33	2.67
Apr 16 (74)A	4.80	3.20	(8.00)		1.60			6.40
Apr 16 (74)B	8.00	6.00			2.00			4.00
Apr 26 (76)A	8.00	6.40	3.20		1.60			4.80
Apr 26 (76)B	8.00	6.00			2.00			4.00
Apr 29 (74)A	(8.00)	3.20	6.40		4.80			1.60
Apr 29 (74)B	8.00	6.00			2.00			4.00
May 9 (77)A	4.57	6.86	2.29	5.72	1.14		8.00	3.43
May 9 (77)B	5.33	6.67		4.00	1.33		2.67	8.00
May 13 (74)A	6.67	8.00	1.33		4.00	2.67		5.33
May 13 (74)B	1.60	8.00			4.80	3.20		6.40
May 23 (75)A	4.80	3.20	(6.40)		(8.00)			1.60
May 23 (75)B	6.00	4.00			2.00			(8.00)
Jun 2 (75)A	6.00	2.00	4.00	3.00	1.00	7.00	6.00	(8.00)
Jun 2 (75)B	(8.00)	2.29		5.72	3.43	6.86	4.57	1.14
Jun 3 (74)A	4.80	6.40	3.20		8.00			1.60
Jun 3 (74)B	6.00	8.00			4.00			2.00
Jun 6 (77)A	8.00	2.29	4.57	3.43	1.14		6.86	5.72
Jun 6 (77)B	5.33	2.67		8.00	1.33		4.00	6.67
Jun 7 (76)A	4.57	8.00	6.86	2.29	5.72		3.43	1.14
Jun 7 (76)B	4.00	8.00		6.67	2.67		5.33	1.33
Jun 17 (74)A	3.20	4.80	6.40		1.60			(8.00)
Jun 17 (74)B	4.00	6.00			2.00			(8.00)
Jun 28 (76)A	5.33	4.00	6.67		1.33	2.67		(8.00)
Jun 28 (76)B	6.40	8.00			1.60	3.20		4.80
Jun 28 (76)C	3.20	4.80	6.40		1.60			8.00
Jun 28 (76)D	4.00	8.00			2.00			6.00
Jul 2 (74)A	4.80	6.40	3.20		8.00			1.60
Jul 2 (74)B	5.33	2.67	6.67		(8.00)	4.00		1.33
Jul 2 (74)C	6.00	4.00			8.00			2.00
Jul 18 (77)A	6.40	3.80	4.80		8.00			1.60
Jul 18 (77)B	8.00	4.00			6.00			2.00
Jul 19 (76)A	8.00	5.33	2.67					
Jul 21 (75)A	8.00	3.20	6.40		4.80			1.60
Jul 21 (75)B	(8.00)	4.00			6.00			2.00
Jul 22 (74)A	4.80	1.60	3.20		8.00			6.40
Jul 27 (76)A	5.33	8.00	6.67		1.33	4.00		2.67
Jul 27 (76)C	(8.00)	4.80	6.40		1.60			3.20
Jul 27 (76)D	6.00	8.00			4.00			2.00
Aug 6 (74)A	1.60	3.20	4.80		8.00			6.40
Aug 6 (74)B	2.00	4.00			6.00			8.00
Aug 12 (74)A	1.60	4.80	3.20		6.40			8.00
Aug 12 (74)B	2.00	4.00			8.00			6.00
Aug 12 (74)C	1.60	8.00	3.20	4.80			6.40	
Aug 12 (74)D	2.00	6.00		(8.00)			4.00	
Aug 12 (74)A	6.40	3.20	3.20		4.80			1.60
Aug 12 (74)B	8.00	4.00	4.00		6.00			2.00
	2.35	1.84	1.99	2.79	2.20	1.97	2.15	2.18
	3.37	2.04	3.19	3.18	2.20	1.97	2.31	2.05
	4.61	3.95	4.98	5.09	5.11	4.87	4.49	3.01

integrated total particulate nitrogen (measure of total biomass, e.g. living plus detritus) proved to be the most influential variables in explaining chlorophyll a (measure of phytoplankton - living - biomass) variability. It has already been noted that the bicarbon ratio (a ratio of the amount of

TABLE 2.4 Rated order

Date	Depth	Ter
Mar 16 (81)A	6.86	3.
Mar 16 (81)B	6.67)	4.
Mar 20 (78)A	5.72	4.
Mar 20 (78)B	8.00	5.
Mar 21 (79)A	5.72	6.
Mar 21 (79)B	(8.00)	6.
Mar 24 (80)A	8.00	6.
Mar 24 (80)B	4.00	5.
Apr 4 (81)A	6.86	3.
Apr 4 (81)B	8.00	5.
Apr 8 (79)A	8.00	6.
Apr 8 (79)B	6.67	8.
Apr 10 (78)A	6.86	3.
Apr 10 (78)B	8.00	4.
Apr 21 (80)A	6.86	8.
Apr 21 (80)B	8.00	5.
Apr 27 (81)A	6.40	3.
Apr 27 (81)B	6.00	4.
Apr 30 (79)A	5.72	4.
Apr 30 (79)B	6.67	5.
May 8 (78)A	4.57	6.
May 8 (78)B	5.33	8.
May 19 (81)A	4.80	6.
May 19 (81)B	8.00	4.
May 28 (79)A	8.00	5.
May 28 (79)B	8.00	4.
Jun 5 (78)A	8.00	3.
Jun 5 (78)B	8.00)	5.
Jun 15 (78)A	6.40	4.
Jun 15 (78)B	4.00	(8.
Jun 25 (79)A	6.40	4.
Jun 25 (79)B	4.00	8.
Jul 4 (78)A	3.20	1.
Jul 4 (78)B	8.00	4.
Jul 13 (81)A	3.20	(8.
Jul 13 (81)B	4.00	8.
Jul 30 (79)A	6.40	3.
Jul 30 (79)B	6.00	8.
Aug 8 (78)A	(8.00)	6.
Aug 8 (78)B	6.00	4.
Aug 10 (81)A	4.57	2.
Aug 10 (81)B	8.00	5.
Aug 25 (80)A	5.72	6.
Aug 25 (80)B	6.67	5.
Aug 27 (79)C	4.80	3.
Aug 27 (79)D	6.00	4.
Sep 5 (78)A	(8.00)	5.
Sep 5 (78)B	5.33	2.
Sep 14 (81)A	8.00	3.
Sep 14 (81)B	8.00)	6.
Sep 17 (79)A	3.43	4.
Sep 17 (79)B	5.33	4.
Oct 5 (81)A	8.00	1.
Oct 5 (81)B	6.00	2.
Oct 10 (78)A	4.80	6.
Oct 10 (78)B	6.00	4.
Nov 14 (78)A	6.40	3.
Nov 14 (78)B	6.00	4.
Nov 16 (81)A	4.57	8.
Nov 16 (81)B	8.00	4.
Nov 19 (79)A	4.57	5.
Nov 19 (79)B	4.00	6.
Dec 7 (81)A	8.00	6.
Dec 7 (81)B	4.00	6.
	4.51	3.
	6.66	4.
	4.53	4.

TABLE 2.4 Rated order of variables 1978 to 1981

Date	Depth	Temp	Secchi	Silica	ITN	ITP	SRP	IPOC
Mar 16 (81)A	6.86	3.43	4.57	6.72	1.14		2.29	8.00
Mar 16 (81)B	6.67)	4.00		8.00	1.33		2.67	5.33
Mar 20 (78)A	5.72	4.57	1.14	(8.00)	6.86		2.29	3.86
Mar 20 (78)B	8.00	5.33		6.67	1.33		2.67	4.00
Mar 21 (79)A	5.72	6.86	(8.00)	4.57	1.14		2.29	3.43
Mar 21 (79)B	(8.00)	6.67		5.33	1.33		2.67	4.00
Mar 24 (80)A	8.00	6.86	3.43	5.72	1.14		4.57	2.29
Mar 24 (80)B	4.00	5.67		8.00	1.33		5.33	2.67
Apr 4 (81)A	6.86	3.43	4.52	5.72	1.14		(8.00)	2.29
Apr 4 (81)B	8.00	5.33		2.67	1.33		6.67	4.00
Apr 8 (79)A	8.00	6.86	4.52	2.29	1.14		3.43	5.72
Apr 8 (79)B	6.67	8.00		5.33	2.67		1.33	4.00
Apr 10 (78)A	6.86	3.43	5.72	4.57	(8.00)		2.29	1.14
Apr 10 (78)B	8.00	4.00		6.77	1.33		2.67	5.33
Apr 21 (80)A	6.86	8.00	3.43	4.57	1.14		2.29	5.72
Apr 21 (80)B	8.00	5.33		6.67	1.33		2.67	4.00
Apr 27 (81)A	6.40	3.20	1.60		4.80			8.00
Apr 27 (81)B	6.00	4.00			2.00			8.00
Apr 30 (79)A	5.72	4.57	6.86	2.29	(8.00)		3.43	1.14
Apr 30 (79)B	6.67	5.33		8.00	2.67		1.33	4.00
May 8 (78)A	4.57	6.86	8.00	2.29	5.72		3.43	6.67
May 8 (78)B	5.33	8.00		4.00	2.67		1.33	(8.00)
May 19 (81)A	4.80	6.40	1.60		3.20			5.33
May 19 (81)B	8.00	4.00			6.00			2.00
May 28 (79)A	8.00	3.20	4.80		6.40			1.60
May 28 (79)B	8.00	4.00			6.00			2.00)
Jun 5 (78)A	8.00	3.43	2.29	6.86	1.14		5.72	4.57)
Jun 5 (78)B	8.00)	5.33		6.67	4.00		5.67	1.33
Jun 15 (78)A	6.40	4.80	3.20		1.60			8.00
Jun 15 (78)B	4.00	(8.00)			2.00			6.00
Jun 25 (79)A	6.40	4.80	3.20		1.60			8.00
Jun 25 (79)B	4.00	6.00			2.00			8.00
Jul 4 (78)A	3.20	1.90	8.00		6.40			1.60
Jul 4 (78)B	6.00	4.00			2.00			8.00
Jul 13 (81)A	3.20	(8.00)	4.80		6.40			1.60
Jul 13 (81)B	4.00	6.00			8.00			2.00
Jul 30 (79)A	6.40	3.20	4.80		8.00			1.60
Jul 30 (79)B	6.00	8.00			4.00			2.00
Aug 8 (78)A	(8.00)	6.40	3.20		4.80			1.60
Aug 8 (78)B	6.00	4.00			8.00			2.00
Aug 10 (81)A	4.57	2.29	(8.00)	6.86	5.72		3.43	1.14
Aug 10 (81)B	8.00	5.33		2.67	4.00		6.67	1.33
Aug 25 (80)A	5.72	6.86	2.29	4.57	1.14		3.43	8.00
Aug 25 (80)B	6.67	5.33		8.00	1.33		2.67	4.00
Aug 27 (79)C	4.80	3.20	6.40		8.00			1.60
Aug 27 (79)D	6.00	4.00			2.00			8.00
Sep 5 (78)A	(8.00)	5.72	3.43	6.86	1.14		4.57	2.29
Sep 5 (78)B	5.33	2.67		3.00	1.33		4.00	6.67
Sep 14 (81)A	8.00	3.20	6.40		1.60			4.80
Sep 14 (81)B	8.00)	6.00			2.00			4.00
Sep 17 (79)A	3.43	4.57	6.68	5.72	2.29		8.00	1.14
Sep 17 (79)B	5.33	4.00		8.00	2.67		6.67	1.33
Oct 5 (81)A	8.00	1.60	4.80		6.40			3.20
Oct 5 (81)B	6.00	2.00			8.00			4.00
Oct 10 (78)A	4.80	6.40	3.20		1.60			8.00
Oct 10 (78)B	6.00	4.00			2.00			8.00
Nov 14 (78)A	6.40	3.20	1.60		4.80			8.00
Nov 14 (78)B	6.00	4.00			2.00			8.00
Nov 16 (81)A	4.57	8.00	3.43	2.29	1.14		6.86	5.72
Nov 16 (81)B	8.00	4.00		2.67	1.33		6.67	5.33
Nov 19 (79)A	4.57	5.72	8.00	3.43	1.14		2.29	6.96
Nov 19 (79)B	4.00	6.67		5.33	1.33		2.67	8.00
Dec 7 (81)A	8.00	6.40	4.80		1.60			3.20
Dec 7 (81)B	4.00	6.00			2.00			8.00
	4.51	3.68	2.51	2.92	1.69		2.47	2.44
	4.66	4.04	2.71	2.92	1.96		2.70	3.00
	4.53	4.99	4.33	5.44	3.09		3.67	4.40

living material to the amount of detritus) for the 0-20 m layer of Lake Ontario is uniform and approximately equal to 12.5%, while the summer ratio is highly variable, ranging from 25 to 50% (MacKinnon and Kwiatkowski, 1980).

Obviously the relationship between detrital pool to living material plays an important role in the variable interrelationships found in this study.

It was found that over 90% of the variation in the size of the algal biomass (as estimated by the chlorophyll *a* concentration) could be accounted for by a multiple regression model typically containing only three variables; namely, integrated total particulate nitrogen, soluble reactive phosphorus and integrated particulate organic carbon, in order of importance. Moreover, the coefficients in the multiple regression models, although varying within each year, appeared to be similar from year to year. It was also noted that the magnitude of the squared multiple correlation coefficient was positively correlated with the size of the algae population; that is, the R-squared values were high when the population was large and low when the population was low. Low R-squared values were consistently found during the summer stratified period, with the physical rather than the nutrient variables being the most influential.

Several explanations exist for why the relationships between chlorophyll *a* and the other physio-chemical variables decrease during the summer stratified period. Chlorophyll *a*/phytoplankton ratios have been found to decrease with decreasing nutrient concentration (.e.g during the summer stratified period, Tolstory, 1979). During summer stratification, phytoplankton populations have been known to settle out of the epilimnion and form a subthermocline chlorophyll peak (Steele and Yentsch, 1960). In Lake Ontario thermocline depth ranges from 15 to 25 meters, and thus the 0-20 m integrator may not have adequately sampled the water column. Good agreements between chlorophyll *a* and direct phytoplankton measurements have been found during the spring, when diatoms dominated in the phytoplankton community. However, this agreement was low in summer when the phytoplankton was dominated by greens and blue-greens (Watson *et al.*, 1975). Bacterial growth (total biomass) has been found to be maximal

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after the diatom peak in algal biomass (chlorophyll a) (Rao et al., 1979). While Mortimer (1974) has proposed that turbulence and internal waves generated by mid-summer seiches within Lake Ontario contribute to the breakup of the major spring chlorophyll a peak through alteration of the physiochemical environment.

Obviously, more detailed observations on the physical and chemical environment, as well as chlorophyll a, phytoplankton, zooplankton and bacterial measurements, coupled with primary productivity data at selected stations, at a frequency greater than monthly, will be required to resolve questions on what regulates summer phytoplankton populations.

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